A COMPARISON OF JNWP TRAJECTORY FORECASTS WITH TRANSOSONDE FLIGHTS

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ABSTRACT

Trajectories at 300 mb. numerically computed from the Joint Numerical Weather Prediction Unit's operational forecasts are compared with transosonde balloon tracks. The method developed by Hubert is shown to provide trajectories of considerable accuracy.

1. INTRODUCTION

In an earlier paper Hubert [1] pointed out the increasing interest in the trajectory of air particles and described a method for approximating such trajectories using an electronic computer. In the preparation of the 72-hour equivalent barotropic forecast at the Joint Numerical Weather Prediction (JNWP) Unit a history tape is produced containing forecast fields of stream function values ψ for a grid of points (see fig. 10) at hourly intervals. Hubert's method involves fitting a general cubic surface to sixteen grid points surrounding the point on the trajectory and the computation of

$$\frac{\partial \psi}{\partial x} \text{ and } \frac{\partial \psi}{\partial y}$$

on this surface. The point is advected with this stream function wind for the next hour after which a new computation is made from the stream function for the next hourly time step at the new location. Non-centered differences were used to avoid computational instability. A variation of this method was used with some success in hurricane forecasting.

The long-range flights of the U. S. Navy transosonde balloons provided an approximation to a two-dimensional trajectory. Accordingly JNWP trajectories were computed on a routine operational basis beginning in November 1957. The comparison of these computed trajectories and the actual transosonde track provides the basis for this paper.

2. METHOD

The transosonde balloons were launched in Japan and set to float at the 300-mb. level. Their position was subsequently determined by 2-hourly HF DF fixes. From the fixes received at Suitland (approximately 40 percent of those theoretically possible) the trans-Pacific tracks were reconstructed and plotted. All fixes were considered to be of equal accuracy. The transosonde program is fully discussed in a recent paper by Angell [2].

*Any opinions expressed by the authors are their own and do not necessarily reflect the views of the Navy Department.
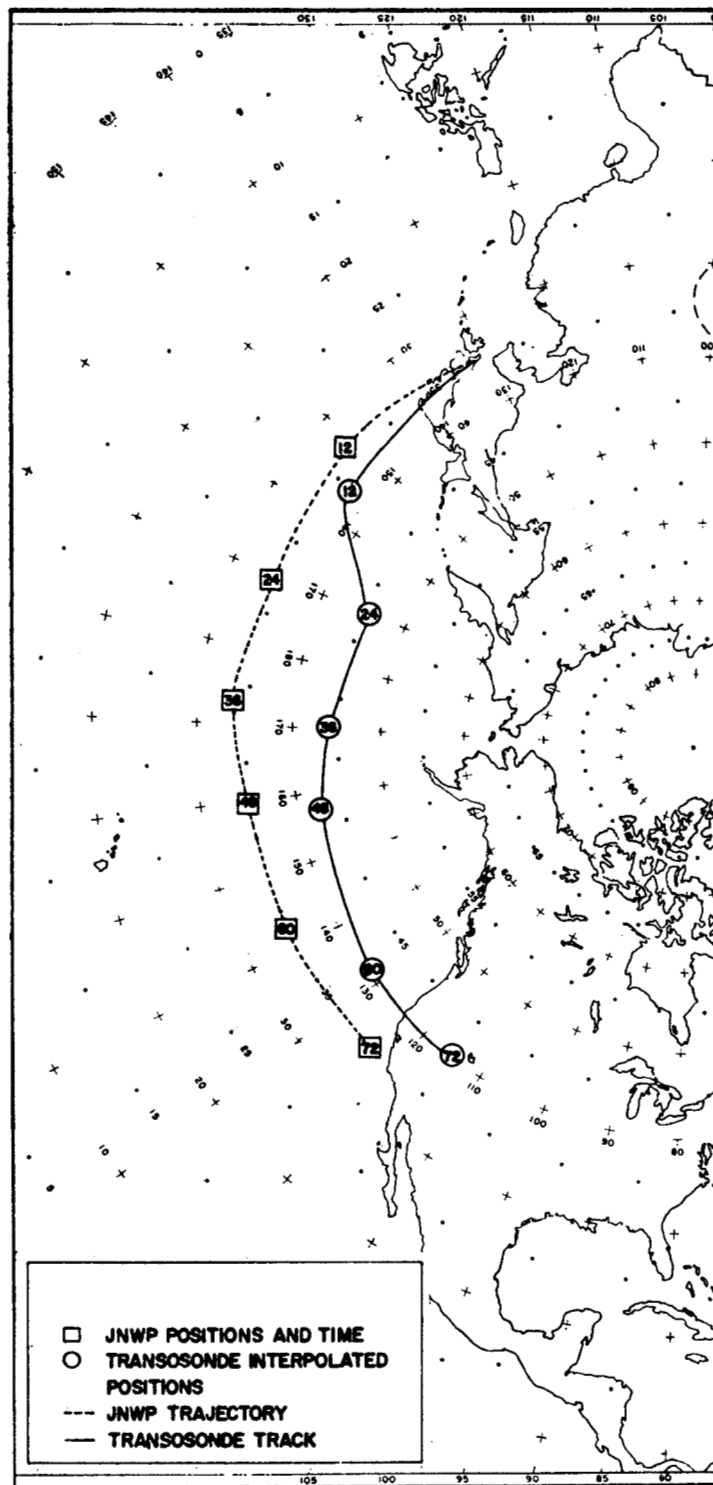

FIGURE 1.—Comparison of JNWP forecast trajectory with transosonde track. Flight No. 38. Release time: 0000 GMT, November 8, 1957.
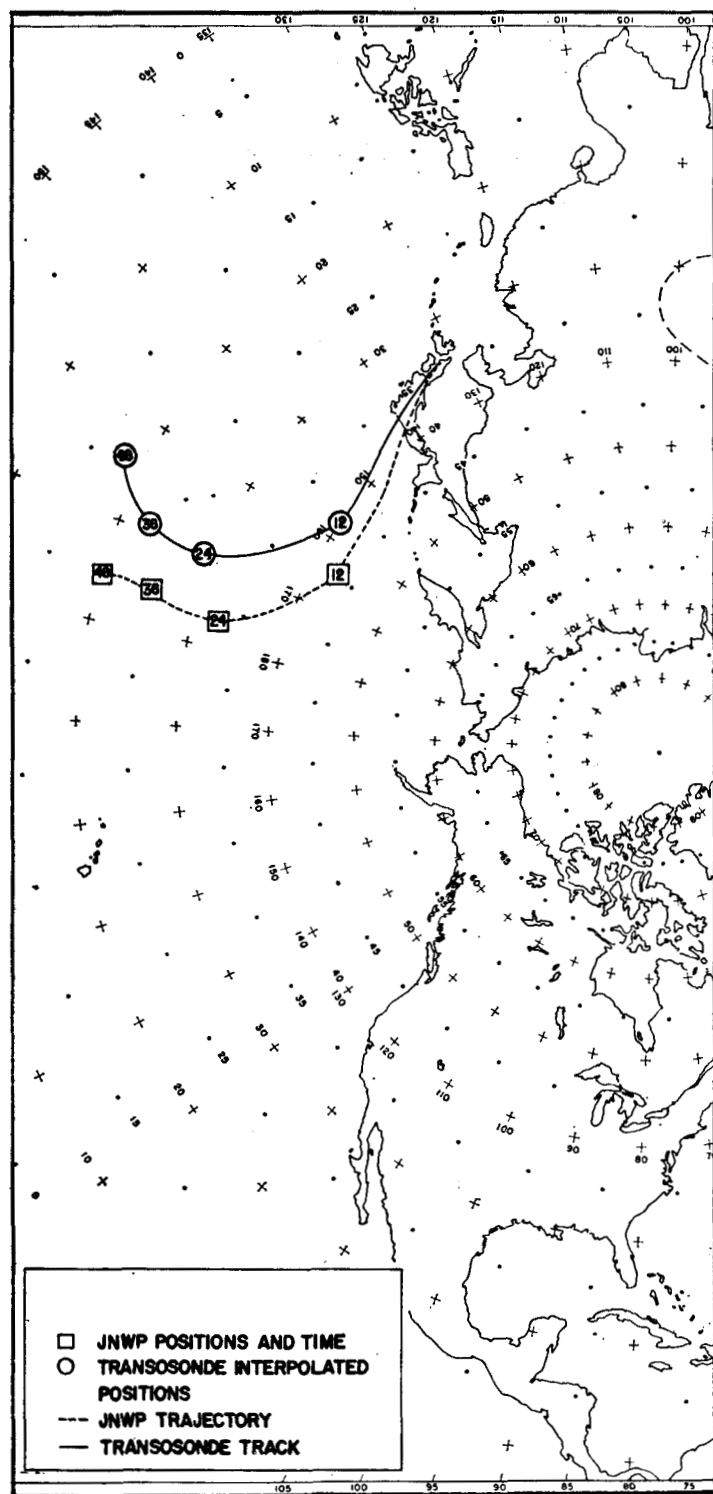
FIGURE 2.—Comparison of JNWP forecast trajectory with transo-
sonde track. Flight No. 40. Release time: 0000 GMT, November
12, 1957.

FIGURE 3.—Comparison of JNWP forecast trajectory with transo-
sonde track. Flight No. 41. Release time: 0000 GMT, November
13, 1957.

To obtain the 300-mb. wind from the 500-mb. stream
function a multiplying factor of 1.75 was used. That is,
300-mb. wind=1.75 times 500-mb. wind. Vederman [3]
found that the proportionality factor, between the pres-
sure gradients at 300 and 500 mb., was approximately 1.5.
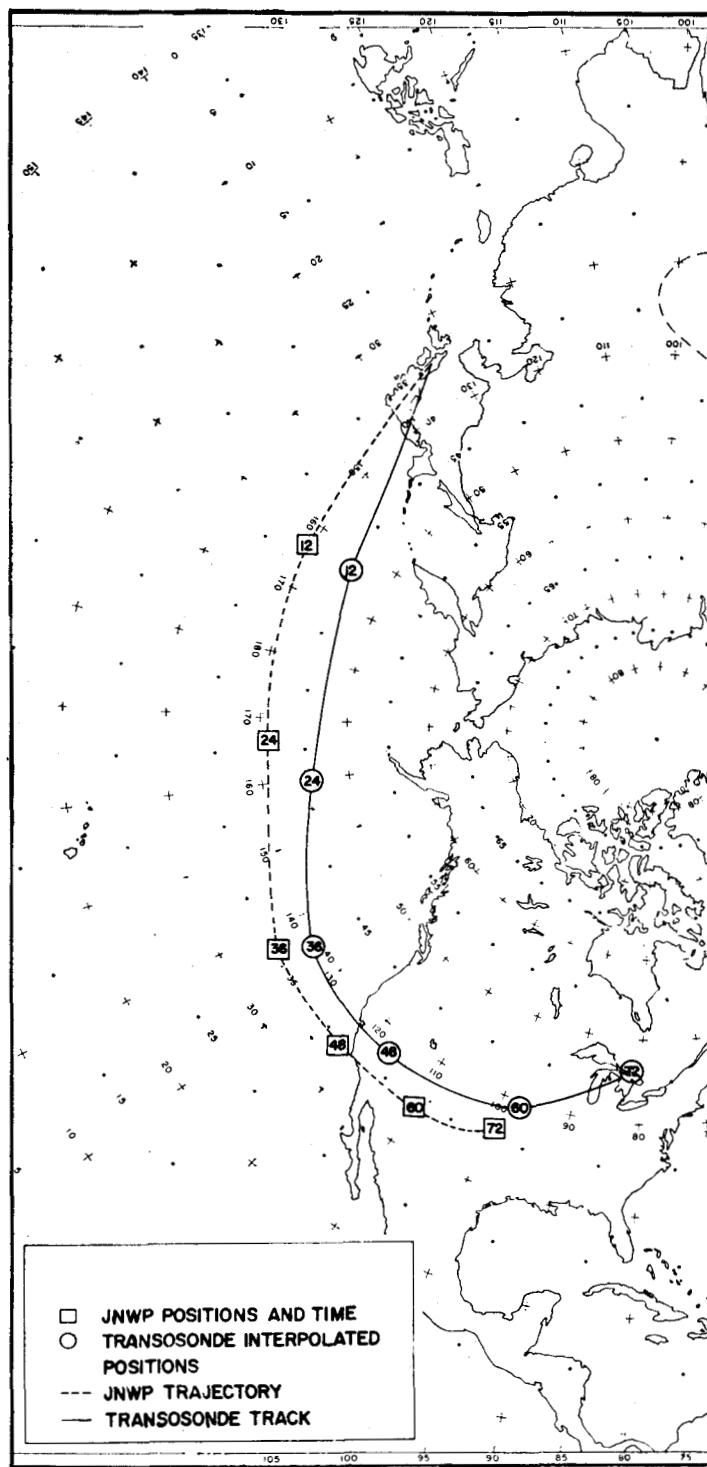The 300-mb. winds obtained by multiplying 500-mb. baro-

tropic forecast height gradients by this factor produced
values which were generally too slow, probably because
of the smoothing effects inherent in the forecast compu-
tations scheme. The factor was increased to 1.75 to bring
the speeds in line with observation.

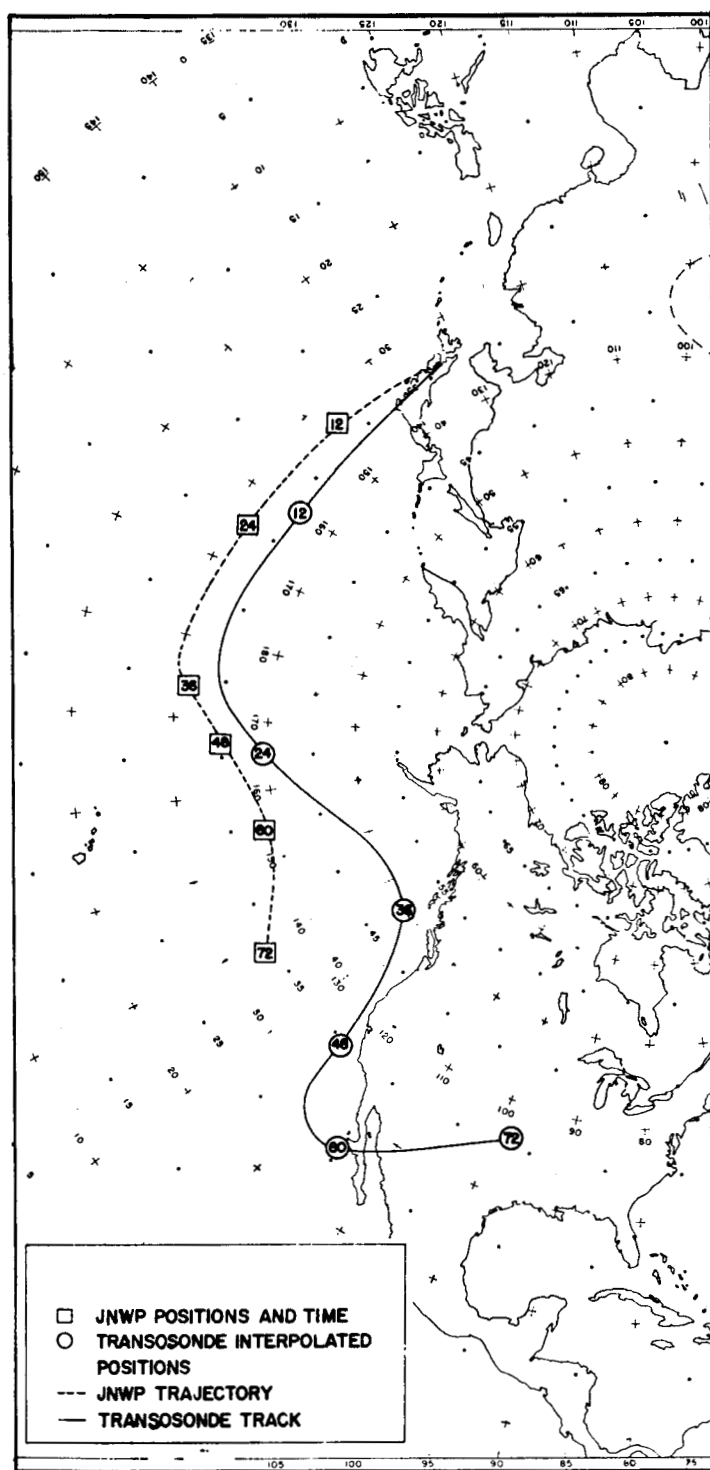The 12-hour positions of trajectory and balloon track

FIGURE 4.—Comparison of JNWP forecast trajectory with transosonde track. Flight No. 43. Release time: 0000 GMT, November 15, 1957.
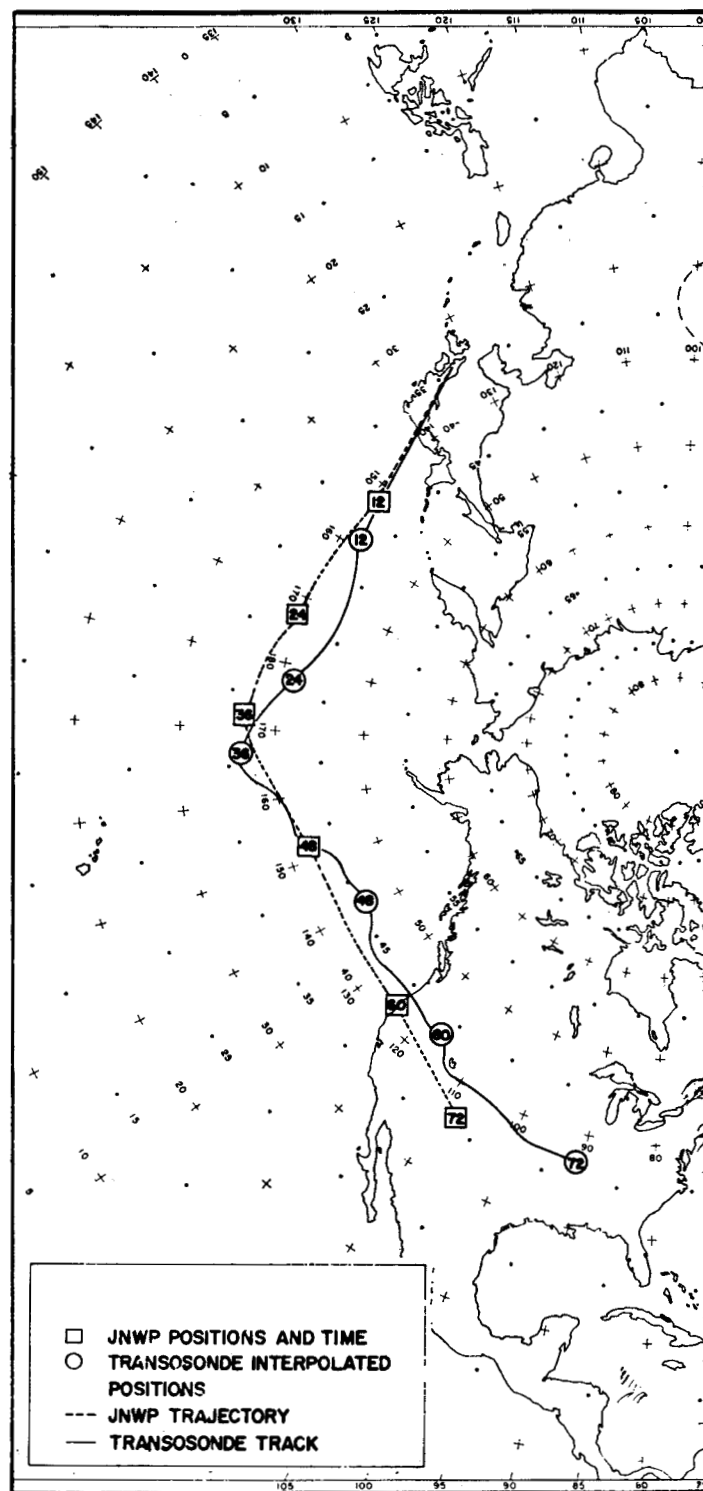
FIGURE 5.—Comparison of JNWP forecast trajectory with transosonde track. Flight No. 44. Release time: 0000 GMT, November 18, 1957.

were plotted to 72 hours. Intervening positions were used where available in reconstructing the paths. The program began with flight 38 launched on November 8, 1957. At the time this paper was prepared eleven pairs of tracks had been recorded. All of these results are shown in figures 1–11.

3. RESULTS

There is considerable agreement between the forecast trajectories and transosonde tracks. An analysis of the vector difference between positions shows no systematic error until 48 hours after which the balloon was ahead
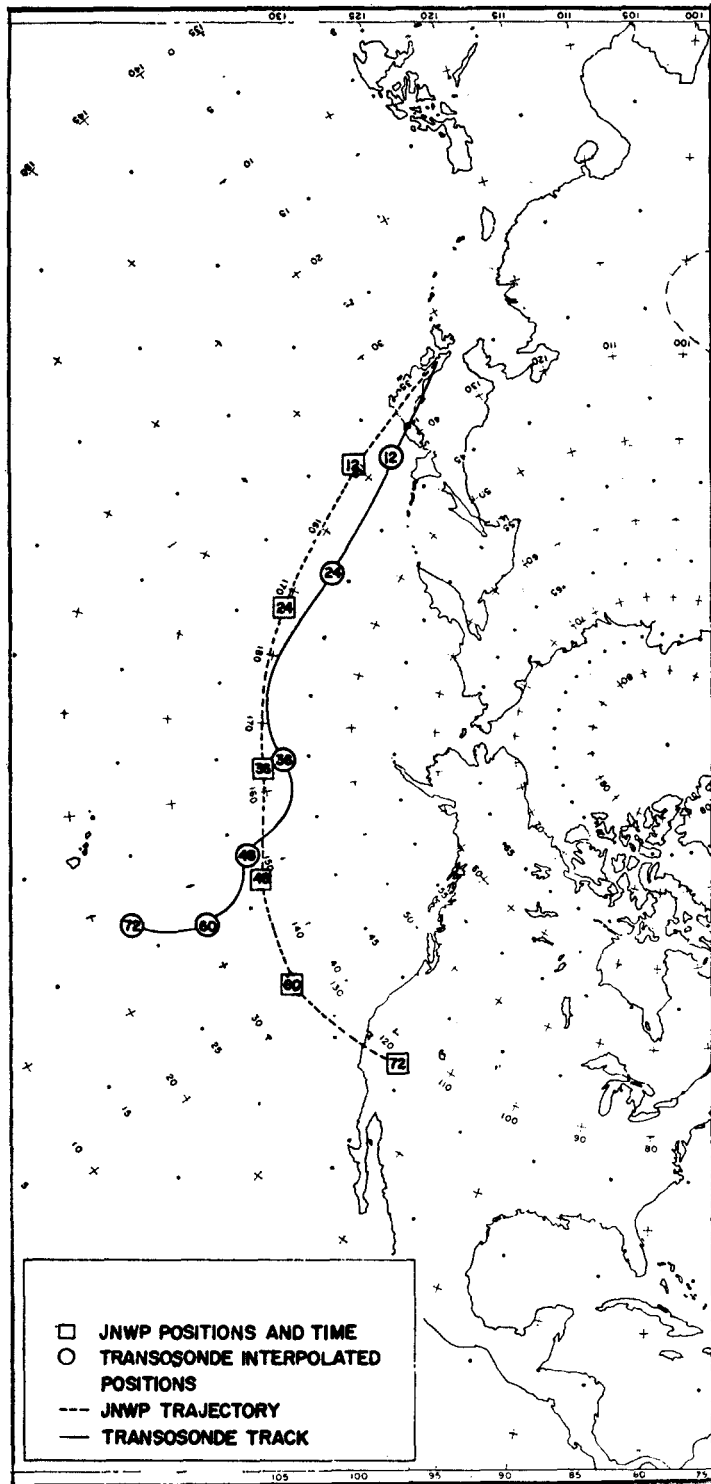
FIGURE 6.—Comparison of JNWP forecast trajectory with transosonde track. Flight No. 47. Release time: 0000 GMT, November 23, 1957.

FIGURE 7.—Comparison of JNWP forecast trajectory with transosonde track. Flight No. 48. Release time: 0000 GMT, November 25, 1957.

and to the north of the forecast trajectory. At 36 hours the average difference in position was approximately 6° latitude which is less than 10 percent of the average distance traveled.

The two special flights (figs. 10 and 11) were released from California. In the first special flight the transosonde
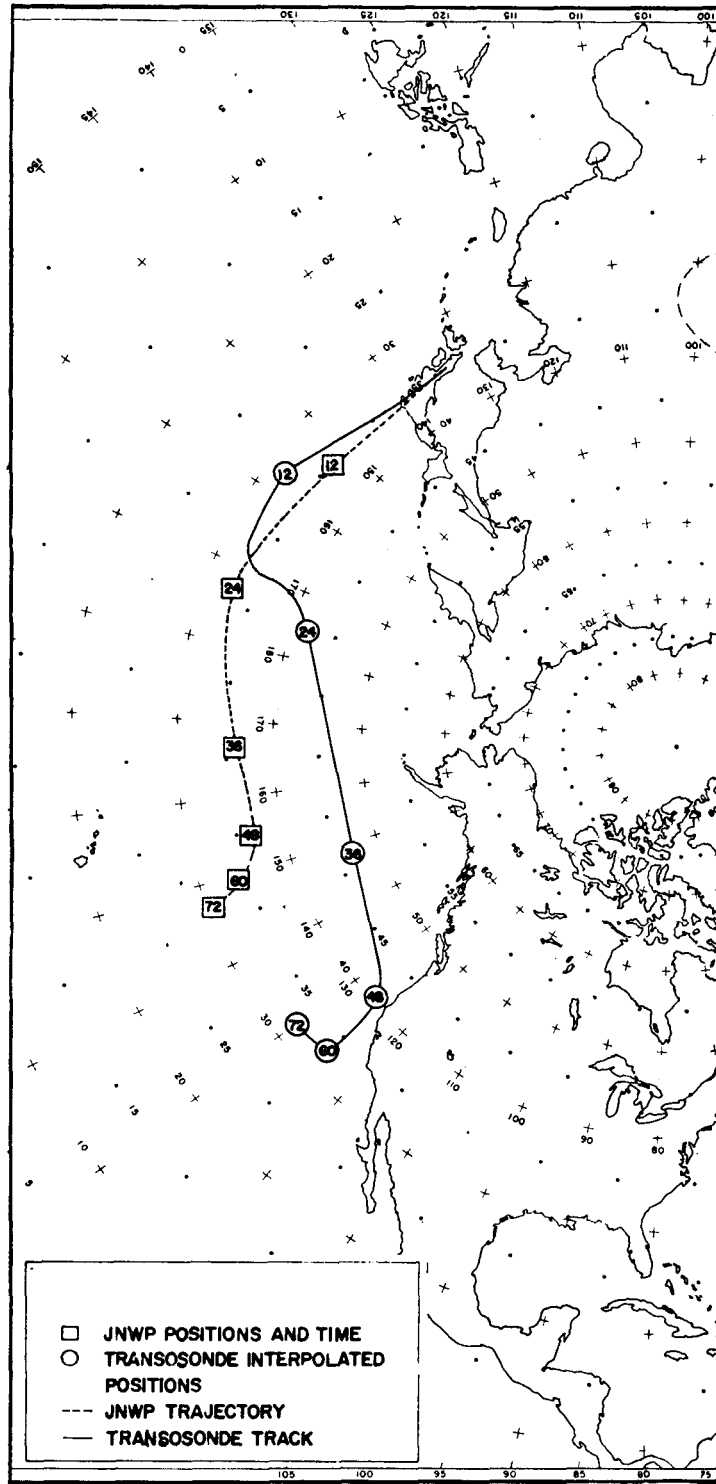
was released into an area of negative absolute vorticity. This probably accounts for the differing paths since the non-divergent stream function is inadequate to describe the local air motions likely to occur under such conditions.

For three of the flights shown, trajectories were computed in 12-hour steps from geostrophic winds scaled
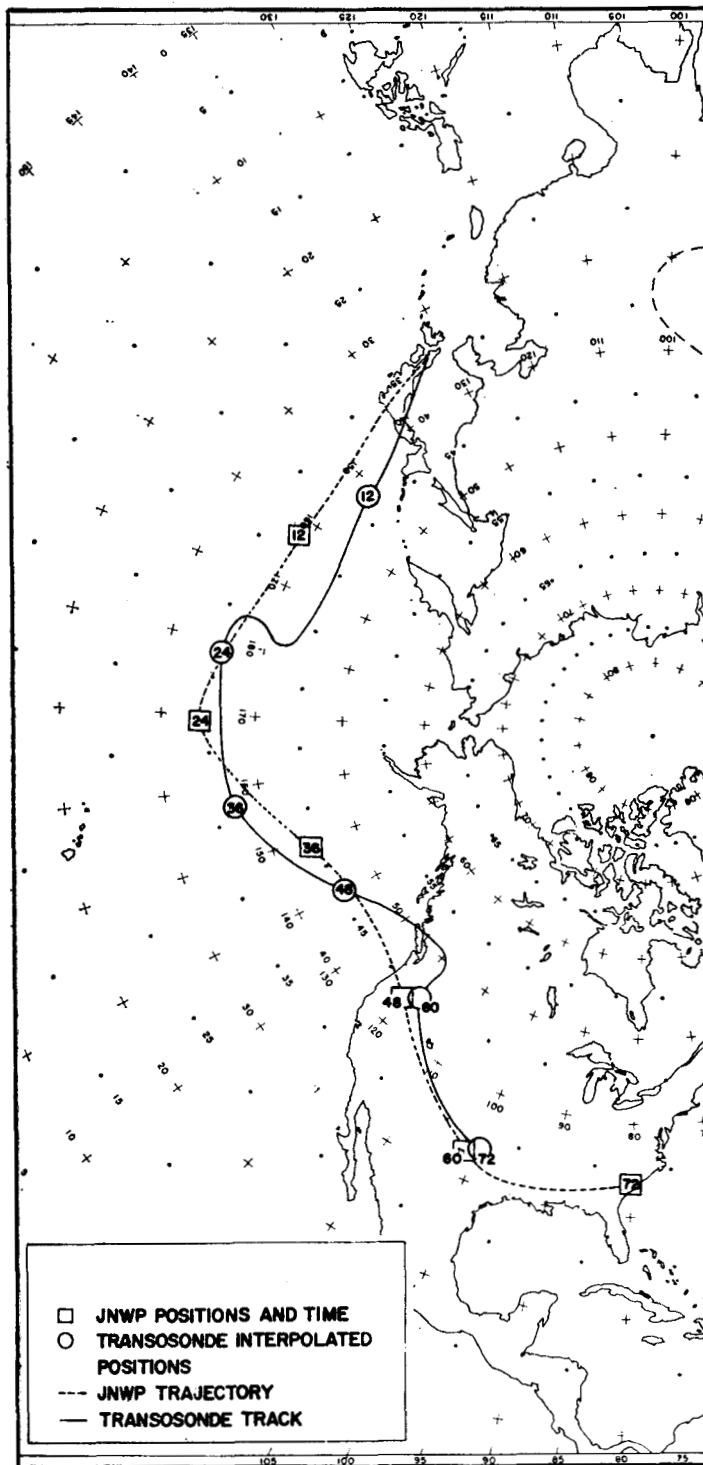
FIGURE 8.—Comparison of JNWP forecast trajectory with transosonde track. Flight No. 49. Release time: 0000 GMT, November 27, 1957.
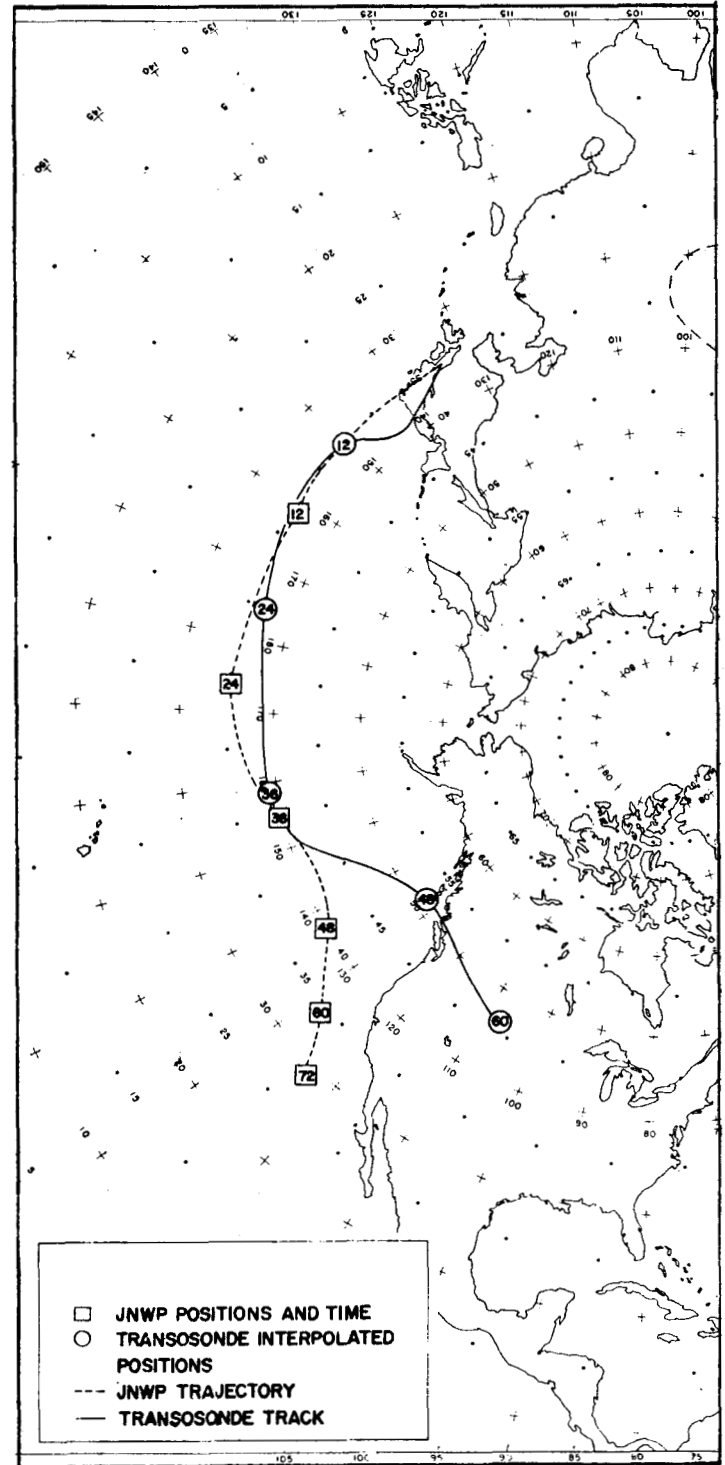

FIGURE 9.—Comparison of JNWP forecast trajectory with transosonde track. Flight No. 51. Release time: 0000 GMT, December 1, 1957.

from actual 500-mb. analyses at JNWP Unit. These trajectories showed less agreement with the transosonde track after 48–72 hours than did the JNWP trajectories from the numerical forecast.

4. CONCLUSIONS

The trajectory computed by this method in one-hourly time steps from the numerical forecast is an excellent approximation to a two-dimensional trajectory for 36
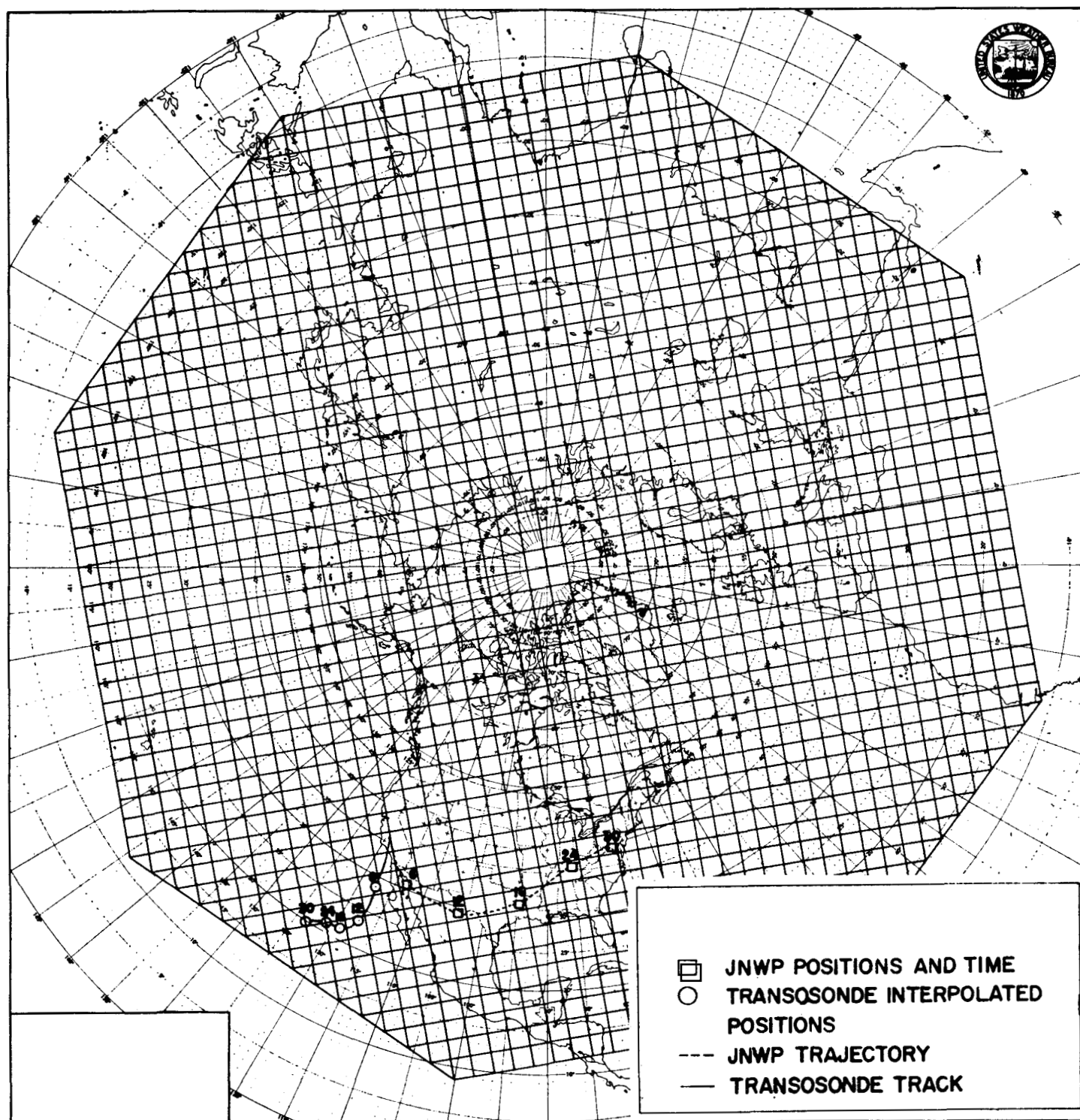
FIGURE 10.—Comparison of JNWP forecast trajectory with transosonde track. Flight Special I. Release time: 1900 GMT, November 12, 1957. The grid shown is the Northern Hemisphere grid used by JNWP in the equivalent barotropic forecast.

hours. This is attributed to a combination of the following: the barotropic model forecasts are a good representation of mid-troposphere flow; Hubert's trajectory method is quite accurate; and the 300-mb. flow is specified well when integrated over considerable time and distance by the 500-mb. wind with the speed increased by the constant factor.

The greater accuracy of the JNWP forecast trajectory over the hand computed trajectory is attributed in some part to the definition of one-hour time steps but more to
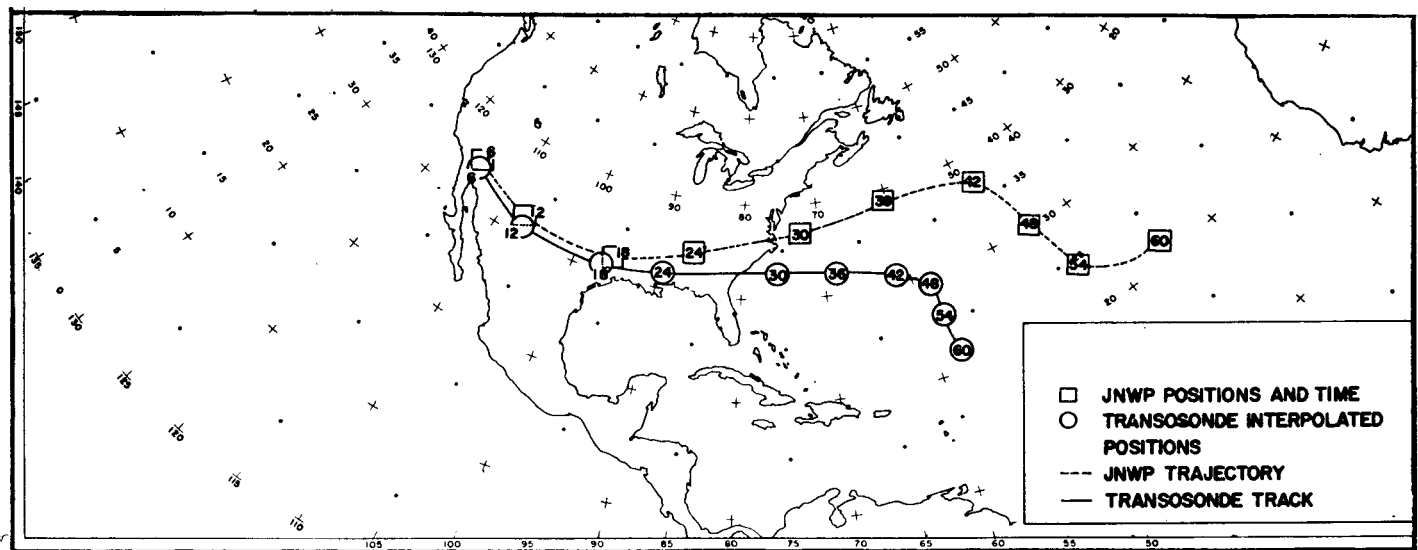
FIGURE 11.—Comparison of JNWP forecast trajectory with transosonde track. Flight Special II. Release time: 0300 GMT, November 21, 1957.

the lack of data in the Pacific which leads to a lack of continuity between analyses. The 72-hour forecast remains consistent with its initial data and, for trans-Pacific computations, is more accurate. This shows that the consistency outweighs the decay in forecast quality for this purpose. It also suggests strongly that wind computations from JNWP stream functions are excellent for longer range aircraft operations.

ACKNOWLEDGMENTS

REFERENCES

1. W. E. Hubert, "Hurricane Trajectory Forecasts from a Non-Divergent, Non-Geostrophic Barotropic Model," *Monthly Weather Review*, vol. 85, No. 3, Mar. 1957, pp. 83–87.
2. J. K. Angell, "The Application of Routine Transosonde Data to Analysis and Forecasting," *Training Paper* No. 13, U. S. Weather Bureau, Apr. 1957, 33 pp.
3. J. Vederman, and B. Dubofsky, Operational Techniques for Forecasting Flow Patterns in the Upper Troposphere, National Weather Analysis Center, U. S. Weather Bureau, 1958, (unpublished manuscript).